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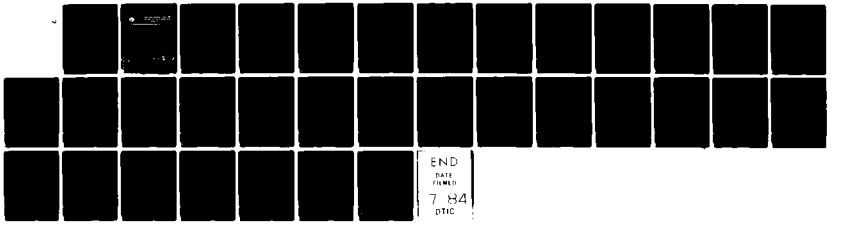

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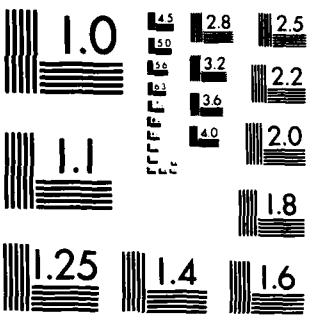

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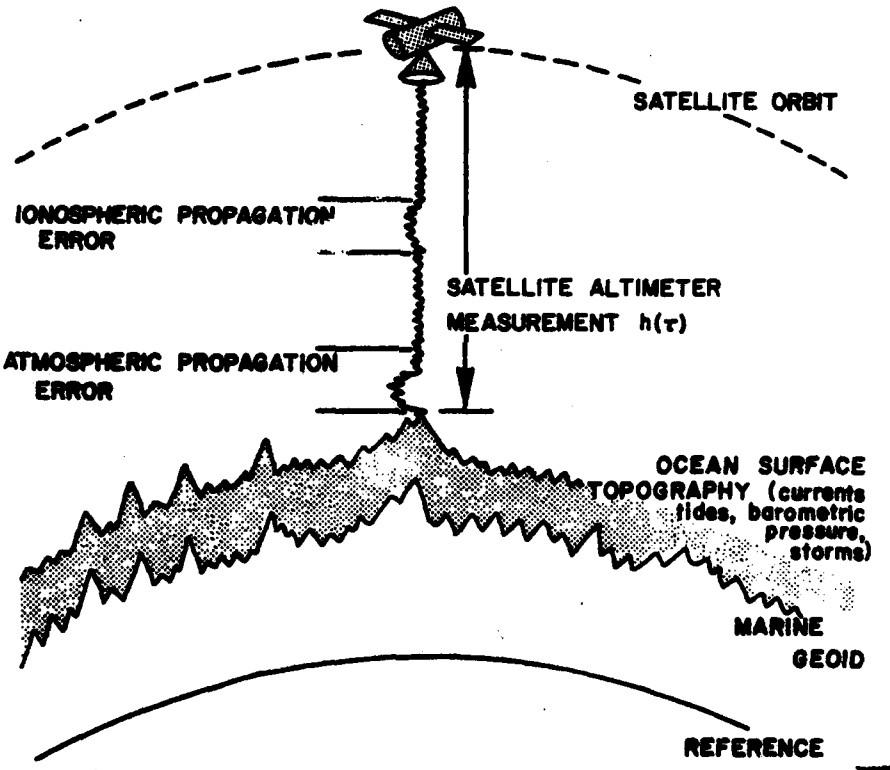
NORDA Technical Note 270

Naval Ocean Research
and Development Activity
NSTL, Mississippi 39529

GEOSAT Ocean Applications Program (GOAP) Initial Data Processing and Analysis System Test and Evaluation Plan



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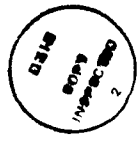
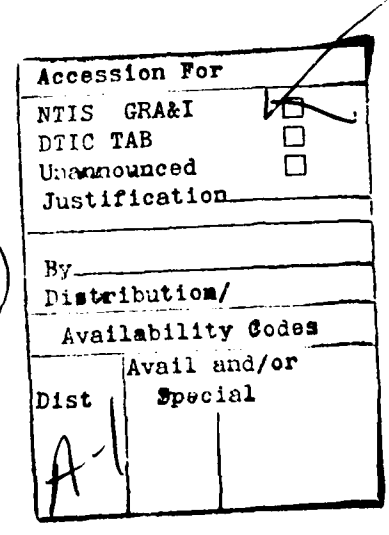
ABSTRACT

NORDA's Remote Sensing Branch will conduct an operational demonstration as part of the GEOSAT Ocean Applications Program (GOAP). The purpose of the demonstration is to evaluate the extent to which oceanographic products can be derived from altimeter data in near real-time. This technical note describes the information processing system that will be used for this task, and plans for its development and testing. It also covers plans for the operation of the system, personnel assignments and training, evaluation of the products, and eventual transfer of the operations to FNOC or NAVOCEANO.





ACKNOWLEDGMENTS

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GEOSAT OCEAN APPLICATIONS PROGRAM (GOAP) INITIAL DATA PROCESSING AND ANALYSIS SYSTEM TEST AND EVALUATION PLAN

1. INTRODUCTION

1.1 PURPOSE OF TEST PLAN

This test plan has been prepared in order to doucment the Navy GEOSAT Program advanced development (6.3) activities that will be performed by the Naval Ocean Research and Development Activity (NORDA) Remote Sensing Branch, It is written:

- To provide an overview of the GEOSAT Ocean Applications Program (GOAP) information processing and a description of the hardware and software that will be used.

- To present an orderly schedule of events, specification of organizational requirements, method of testing, and a schedule of user orientation.

- To establish a comprehensive test plan and to communicate the nature and extent of the tests deemed necessary to provide a basis for evaluation of the system.

- To describe the demonstration products and their ingredients.

- To describe the demonstration telecommunication system.

- To describe the field verification activities.

1.2 ORGANIZATIONAL INVOLVEMENT

Table 1.1 is a matrix that shows action organizations, actions that have been, or will be performed, and time frames.

2. DEVELOPMENT TEST ACTIVITY

2.1 BACKGROUND

NORDA, under separate funding, is developing a satellite receiving/processing facility. That processing facility has been upgraded to support GOAP by the purchase of two Gould SEL 32/27 32-bit minicomputers with associated peripherals. Table 2.1 lists the hardware and system software for the upgraded satellite processing facility.

As part of the GOAP program, NORDA is also supporting the development of the GEOSAT oceanographic information processing system. Four stages are involved in the development of the system: planning, implementation, demonstration and evaluation, and the operation phase. The developmental study for the information processing system took into account hardware/software and software/software interfaces, data queues, and data processing. A Conceptual Design Review was held in October 1982. The Critical Design Review for the APL/NORDA telecommunications link was held in May 1983.

Table 1.1. Significant actions, participants, and dates.

	APL	CONTRACTOR(S)	FNOC	JPL	NAVELEX	NAVOCEANO	NORDA*	NRL	REGIONAL CENTERS	Time Frame or Completion Date
Project Management							x			Continuing
Processing Software										
Conceptual Design				x						Dec 82
Communication Software:										
Write	x									Aug 83
Provide to NORDA	x									Dec 83
Prepare Simulated GEOSAT Test Tape								x		Nov 83
Provide Processing Hardware							x			Dec 83
Plan for FNOC Assimilation of Products		x	x				x			Jun 84, continuing
Communication/Crypto Gear:										
Coordinate Acquisition					x					Feb 84
Technical Support	x				x					
Data Line testing	x	x					x			Feb-Aug 84
GOAP Processing Software		x				x	x			Aug 84, continuing
Procesing System Testing:										
Prepare Plan		x					x			Apr 84
Perform Testing		x					x			Apr-Sep 84
Launch	x									Nov 84
GOAP System Checkout		x					x			Jan 85
Demonstration	x	x	x			x	x			Feb 85, continuing
Operatonal Evaluations										
Initial						x	x			FY85 Q2 & Q3
Ongoing			x			x	x		x	FY85/86
Orientation & Training		x					x			FY85
Transition to FNOC or NAVOCEANO		x	x				x			FY 86

*NORDA will use several consultants/advisors who have expertise in specific areas.

Table 2.1. NORDA satellite processing facility system components.

Item No.	Qty.	Model No.	Description
1	1	3428	SEL 32/27 with 2 MB MOS memory, CPU with floating point, IOP, 10 SelBUS + 5 MP BUS slots
2	1	3901	SEL 32/27 CPU Cabinet
3	1	3443	SEL 32/2750 with 2 MB MOS memory, CPU with floating point, IOP, 18 SelBUS + 8 MP BUS slots
4	1	3902	SEL 32/2750 CPU Cabinet
5	2	8610-2	Console CRT
6	3	9131	HSD Interfaces
7	1	9135	Intercomputer Bus Line - 50' Cable
8	2	8511	8 Line Asynchronous Mux
9	2	8580	RS 232 Distribution Panel for 8511
10	2	8140	Single 300 MByte disc with controller
11	1	8212	Single 125 IPS - 800/1600/6250 BPI tape drive with high speed controller
12	1	8290	High Speed Mag Tape Cabinet
13	1	1401-0201	MPX Version 2.1 A - Operating System
14	1	1411-0201	Scientific Runtime Library
15	1	1413-0201	Fortran 77+

After launch of GEOSAT in early FY-85, the hardware and software system will be used in an operational demonstration, which is intended to evaluate the extent to which oceanographic products can be derived from altimeter data in near real-time. The first 12-18 months of the demonstration will be conducted at NORDA; subsequently, the responsibility for conduct of the demonstration will be transferred to either Fleet Numerical Oceanography Center (FNOC) or the Naval Oceanographic Office (NAVOCEANO) in accordance with Reference 20.

Several organizations and locations are involved in the operational demonstration and the preparation for it. The GEOSAT satellite will be built by the Johns Hopkins University Applied Physics Laboratory (APL); the ground receiving site will be at APL. APL will perform some preliminary data processing and transmit the results to NORDA. (Satellite data dumps will occur about once every 12 hours. Sometimes, partial dumps may occur on consecutive passes.) NORDA will analyze the data to provide wind and wave information over open ocean areas as soon as possible after receipt of the data from APL, seven days per week, ice edge location every 24 hours, and information on mesoscale ocean features in selected areas every 24 hours, five days per week. The calculations will require oceanographic fields and other oceanographic data to be transmitted from FNOC to NORDA. The results of the analysis will be transmitted from NORDA to FNOC according to the schedule given above. Both APL and Jet Propulsion Laboratory (JPL) were under contract to NORDA in FY-82 and FY-83 to help prepare for this operational demonstration. The two laboratories have unique capabilities in complementary aspects of the problem. NRL is also providing assistance in sensor performance validation and similar areas. Computer Sciences Corporation (CSC), the on-site contractor, will provide support in detailed software design and implementation, and in implementation of data link hardware and software. NORDA will manage the GOAP information processing system development, supported by several advisors/consultants. NAVELEX is providing overall management coordination for GOAP.

2.2 PRETEST ACTIVIY

2.2.1 Data Links

APL will transmit to NORDA a "NORDA Data Record" (NDR), which will be a data stream that consists of a header frame and multiple data frames [13]. The NDR will be encrypted and transmitted to NORDA via a new 9.6 kb/s communication line. Encryption is required because the raw altimeter height words will be classified SECRET. At NORDA the data stream must be decrypted and input to the SEL 32/2750 computer system via an interface unit. A similar link will be required to transmit products from NORDA to FNOC; the mesoscale product will also be SECRET. NORDA must also receive FNOC fields, such as EOTS analysis results. That data volume is low compared to the GEOSAT data. Encryption/decryption are not required for fields such as surface temperature and pressure, and surface water vapor pressure, but will be required for BT data. A new dedicated communication line will be used for NORDA-FNOC communication.

Hardware and software compatibility between the different sites is important. APL has procured the following SEL interface hardware to support the APL-NORDA GOAP communications link: Model 9116 Binary Synchronous Line Interface Module (2 needed), Model 9103 General Purpose Multiplexer Controller, and Model 9305 General Purpose Device Controller Chassis. NORDA has purchased similar equipment. The data line between APL and NORDA will be specified to have technical performance equivalent to Dataphone Digital Service (DDS). Other communication link hardware required includes modems (provided with data line) and encryption/decryption gear (to be provided

GFE). APL has written the communication and file management software and provided it to NORDA. The transmission protocol will be (IBM standard) binary synchronous.

FNOC is in the process of converting to the Advanced Data Communication Control Procedures (ADCCP) communication protocol, which is the American National Standards Institute (ANSI) bit-oriented data link control procedure standard. ADCCP is a derivative of the International Standards Organization's (ISO) high-level data link control (HDLC) protocol. The communications software available for SEL computers uses as a basic link control procedure the Link Access Procedure B (LAPB) of X.25 1980, as recommended by the Consultative Committee for International Telephony and Telegraphy (CCITT). It corresponds to the asynchronous balanced mode subset of HDLC. FNOC has suggested that they could use a PDP-11/34 computer for which an off-the-shelf X.25 communications package is available. The hardware interface to the NORDA computer will be the SEL Model 8520 Synchronous Communications Multiplexer (SCM). The associated SEL software is the Advanced Communication Executive (ACX-32) Level 2. The communication line will be specified to have C4 conditioning.

2.2.2 NORDA Satellite Receiving Facility and GOAP Data System

The NORDA RFP for a turnkey satellite receiving system was modified to specify that the processors used in the system would be two (GFE) Gould SEL 32/27 32-bit minicomputers, with one allociated for use by GOAP. That processor became available for use in December 1983.

The two Gould SEL 32/27 computers and associated peripherals and software, as described in Table 2.1, will upgrade the NORDA satellite processing facility to enable it to support GOAP and other NORDA research efforts. Additionally, GOAP will make use of satellite IR imagery obtained via the satellite receiving facility. Table 2.2 lists details of the satellite imagery that will be available from NORDA's facility.

The previously described data links and the NORDA satellite receiving/processing facility are important elements in the GOAP information processing system. Other elements are the software modules that will process the information at NORDA. NORDA and its contractor(s) will design the software system to run on the NORDA GOAP computer. Plans for the APL GOAP software and its testing are described in the GEOSAT-A Ocean Applications Program APL/NORDA Data Link Program Plan [1]. More details on the NDR are given in Reference 13.

JPL's preliminary system-level plan for information processing development [2] addresses two primary and two secondary functional requirements. The primary requirements are:

- Provide wind and wave reports approximately every 12 hours to FNOC. Wind speed and significant wave height will be contained in the NDR and can be passed on with only minor processing (editing and averaging). This is consistent with FNOC's timeliness requirements for the data. In cases when only a portion of a 12-hour period of data is dumped from the satellite and transmitted to NORDA, the available data (likely to be from the most recent time period) will be forwarded to FNOC without waiting for the remainder.

- Provide a mesoscale oceanography analysis for selected areas every 24 hours to FNOC. Current plans call for NORDA to develop the methodology to interpret the mesoscale analysis in order to provide an Expanded Ocean Thermal Structure (EOTS) bogus file; this capability will be ready in the FY-86/87 time frame.

Table 2.2. NORDA satellite data collection system.

DATA AVAILABLE

Satellite	Sensor	Type Data	Spectral Bands	Spatial Resolution	Repetition Rate	Areal Coverage	Comments
NOAA-7 & NOAA-8							Orbiting (833 and 870 km)
	AVHRR (HRPT)	Digital Imagery	.58 - .68 μm .725 - 1.10 μm 3.55 - 3.93 μm 10.5 - 11.5 μm 11.5 - 12.5 μm	1.1 km (Subpoint) 4 km (Edge)	12 hrs each Satellite	~2200 x 6200 km	Direct Readout (local area)
	(LAC)	Digital Imagery	.58 - .68 μm .725 - 1.10 μm 3.55 - 3.93 μm 10.5 - 11.5 μm 11.5 - 12.5 μm	1.1 km (Subpoint) 4 km (Edge)	12 hrs each Satellite	~2200 x5000 km (Selected Global)	Recorded data Relayed via DOMSAT*
	(GAC)	Digital Imagery	.58 - .68 μm .725 - 1.10 μm 3.55 - 3.93 μm 10.5 - 11.5 μm 11.5 - 12.5 μm	4 km (Subpoint) 16 km (Edge)	12 hrs each Satellite	~2200 km x Complete pass (Selected Global)	Recorded data Relayed via DOMSAT*
	TOVS (HIRS/2) (SSU) (MSU)	 Digital Data Digital Data Digital Data	 VIS thru CO_2 in IR 15 μm 5.5 μm O_2 Band	 17.4 - 58.5 km 147 km 124 km	 12 hrs each Sat 12 hrs each Sat 12 hrs each Sat	 2240 km swath width 2240 km swath width 2240 km swath width (Global via DOMSAT)	Direct readout (local area) and DOMSAT*
	DCS	Platform Information	Environmental Measurment (e.g., temp. pressure, altitude	NA Location accuracy of platform is 3-5 km	6 hrs	Global	ARGOS DCLS by CNES of France Relayed via DOMSAT*

*DOMSAT is RCA communications satellite in geostationary orbit utilized for relaying NOAA 7 & 8 data from NOAA's command and data acquisition stations.

Table 2.2 (continued). NORDA satellite data collection system.

DATA AVAILABLE

Satellite	Sensor	Type Data	Spectral Bands	Spatial Resolution	Repetition Rate	Areal Coverage	Comments
DMSP	OLS	Digital Imagery	0.4 - 1.1 μm (Day) 0.45 - 0.9 μm (Night) 10.2 - 12.8 μm	"Fine" -0.6 km "Smooth" 2.8 km	12 hrs each Satellite	2900 km swath	Orbiting (835 km) Direct readout (local area) + FNOC global windows
	SSM/I	Digital Imagery	19.35 GHz (H, V) 22.235 GHz 37.0 GHz (H, V) 85.5 GHz (H, V)	69 x 41 km 60 x 36 km 35 x 22 km 16 x 10 km	12 hrs each Satellite	1395 km swath width	Future sensor (1985) Direct readout (local area) + FNOC global windows
GOES EAST & GOES WEST	VISSR	Digital Imagery	.55 - .75 μm 10.5 -12.6 μm	.8 km (vis) 8.0 km (IR)	30 mins each satellite	4000 x 4000 km (Vis) Full disc (IR)	Geosynchronous Separate antennas for each satellite

• A recently-added requirement (not addressed in the JPL plan) is for sea ice edge location daily on a near-real-time basis. Reference 10 requests and Reference 14 validates the requirement for this product. The information will be provided to FNOC, which will incorporate it into the ice product that they prepare for Naval Polar Oceanography Center, or prepare an independent plot. New FNOC software may be required for this purpose.

The secondary requirements are:

• Provide the capability to evaluate, and then enhance, the data products during the demonstration and evaluation phase.

• Provide the capability to determine system performance and assist in problem isolation in the complete end-to-end system (interface to mainline GEOSAT program, GOAP data processing system, FNOC data processing system, and the communications lines). This system will form the baseline for the N-ROSS (Navy Remote Ocean Sensing System) altimeter processing.

These functional requirements translate into requirements for several types of resources and capabilities:

• Interactive data recall, display, and manipulation capabilities.

• Software development tools and resources

• Supporting data types such as composite infrared contour maps, bathythermograph data, and FNOC fields (e.g., EOTS analysis results).

There are significant problems associated with the preparation of a daily mesoscale product. The altimeter will be *nadir-looking* with a "swath" only a few km (depending on sea state) wide. The ground track pattern that will be laid down over a six-month period will provide several "cuts" through an area the size of even a small eddy located anywhere on the globe (between 72°N and 72°S, the limits of coverage by GEOSAT). However, the slow fill-in and other characteristics of the track laydown will cause severe sampling problems. In particular, the cross-track sampling of a moving feature will be severely distorted. Also, long periods (of order months) may elapse during which a mesoscale feature may be missed entirely. This last problem, in particular, conflicts with the requirement for a daily mesoscale product. These points are discussed in more detail by Mitchell [15].

The analysis approach that NORDA will employ is interactive image processing. A human analyst will view altimeter height residuals, in plan and profile form, along with other information (e.g., satellite infrared imagery, bathymetry, XBT observations) and make subjective decisions about the mesoscale feature content revealed by the ensemble of data. NORDA supports the development of objective techniques to detect and monitor the desired feature types, but the interactive approach provides the best "payoff" potential in the time available for development.

FNOC has tasked NORDA (Code 322) to develop several techniques in connection with the FNOC Optimum Thermal Interpolation System (OTIS). Among these is a recommendation of the best approach for objective assimilation of GEOSAT altimetry data into OTIS, and the initial design of software necessary to implement this recommendation.

The major milestones in the GOAP data system development are listed in Figure 2.1 and described below. Figure 2.2 gives the schedule for development of elements of the data system software. NORDA's on-site technical support contractor will implement most of the NORDA software. NAVOCEANO has provided a LANDMASK program to produce a land-sea boundary mask from the CIA World Data Bank II. Another NAVOCEANO-provided program is GEORES, which contains an interpolation routine for use with the high-precision geoid. The NSWC program RPTIDE will be used in the calculation of the tidal correction [16]. Also, a procedure that was used by NSWC for SEASAT data will be used to edit out bad data values [18]; NORDA will write new software that implements this procedure. The NAVSPASUR program PPT1 will be used for ephemeris calculations. The on-site contractor will also integrate the major software modules with each other, with the operating system, and with the hardware. APL has provided line control and file management software to NORDA, along with assistance in conversion and implementation. Plans for system testing and evaluation are being prepared by NORDA and its software contractor.

The schedule of activities must be coordinated with APL's schedule for development of (their portion of) the GOAP software and data link. That schedule, which appears in their Data Link Program Plan [1], calls for system (hardware and software) integration to be completed in March 1984. Some APL milestones that are closely tied to milestones for the NORDA site are also shown in Figure 2.1.

After launch of the satellite, approximately 30 days will be required for orbit stabilization, satellite system "health" verification, sensor data validation, etc. NORDA plans an additional 30-45 day test period after operational data transmission from APL begins to provide a preliminary operational evaluation of the information system.

2.2.3 SEASAT Simulation

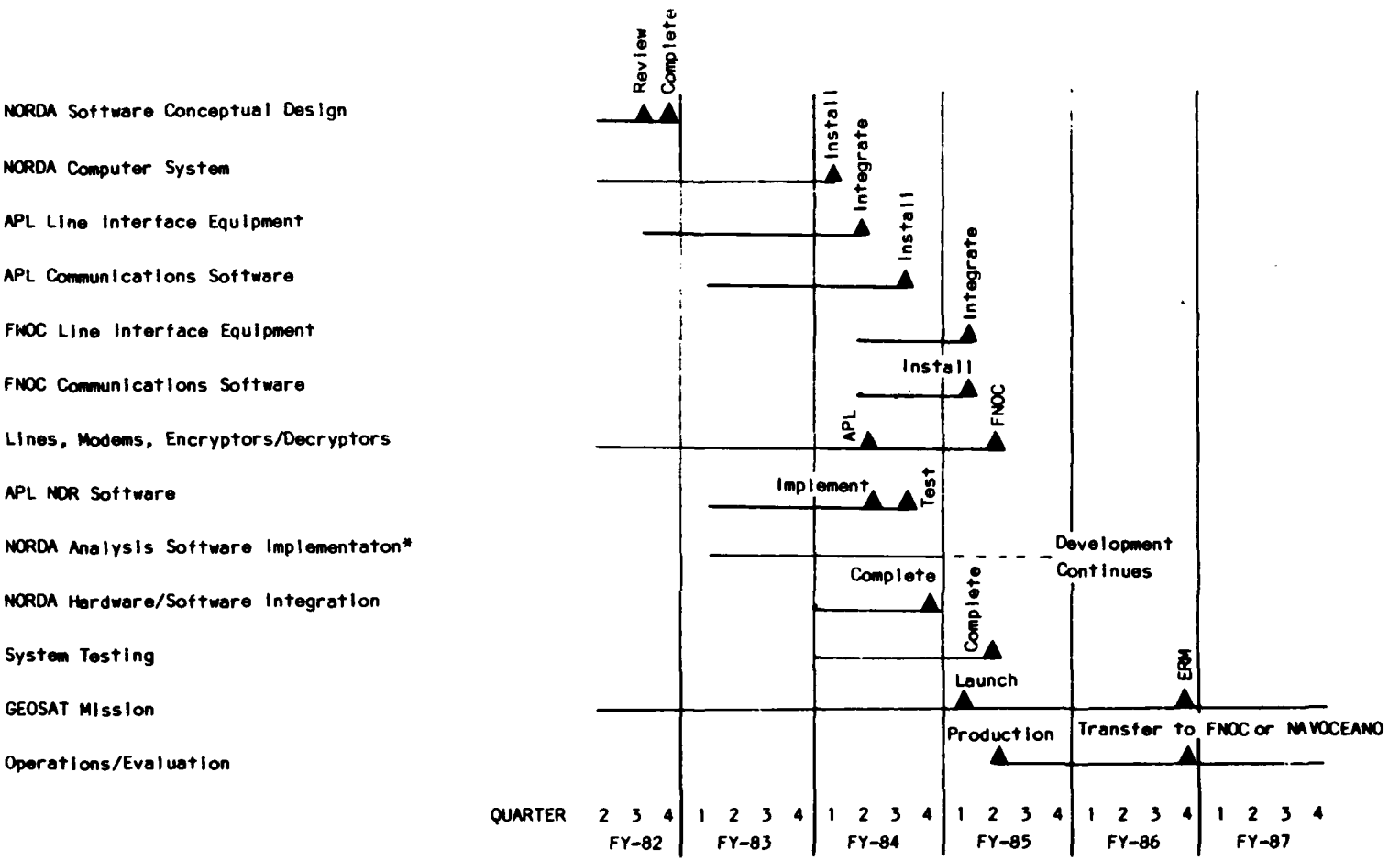
The SEASAT Simulation project is complementary to the GOAP operational demonstration. The program objectives are to develop and test methods and software for analysis of GEOSAT altimetry and ancillary data by using existing data consisting of concurrent sets of:

(1) SEASAT/GEOS-3 altimetry;
(2) NOAA-5/GOES IR SSTs;
(3) SEASAT SMMR data;
(4) In situ data (e. g., hydrography).

Despite considerable difference in the spatial resolution and sampling strategy of anticipated GEOSAT altimetry and GEOS-3/SEASAT altimetry, use of the existing data should potentially set the stage for the GEOSAT demonstration. Many of the specific details of the processing steps required to produce meaningful GEOSAT mesoscale products will be defined by the simulation activities using existing data or, in some cases, simulated data. Although not the primary objective of this work, it is anticipated that new insight and processing expertise also will be developed for the DMSP SSM/I (based on the SEASAT-SMMR experience).

Progress to date, which has been somewhat slowed by slippage in the delivery date for the NORDA SEL/I^2S system, consists of:

- Acquisition of satellite IR imagery, SEASAT SMMR, and SEASAT/GEOS-3 altimetry for two initial simulation areas (NW Atlantic and Gulf of Mexico) is complete.



*See Figure 2.2

Figure 2.1. GOAP data system major milestones.

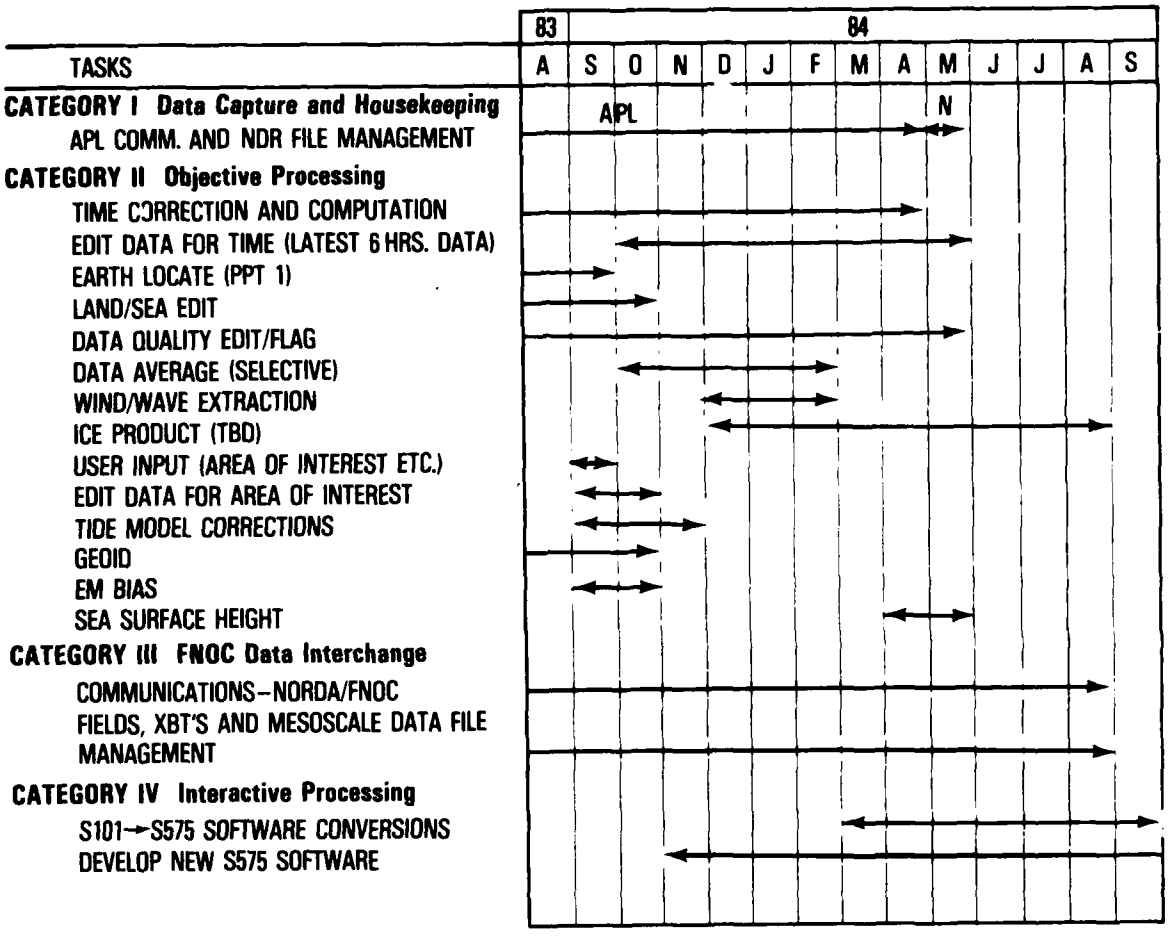


Figure 2.2. NORDA GOAP software development schedule.

• Cloud-free composites of IR images [8] for NW Atlantic area have been produced for all possible time periods concurrent with SEASAT.

• Maps of residual (dynamic) topography have been produced in NW Atlantic area using SEASAT/GEOS-3 altimetry and Marsh-Chang geoid.

• Synthetic Bathymetric Profiling System (SYNBAPS) bathymetry and geoid have been compared for aid in analyzing problems noted in the dynamic topography maps and which are the result of geodetic contamination of these residuals.

Anticipated progress through the end of second quarter of calendar year 1984 consists of:

• Analysis of available in situ data in simulation regions using the MOODS data base.

• Development of procedures for production of GEOSAT mesoscale product using all existing data (along with simulations) in order to more specifically define interfaces addressed in the next version of this Test and Evaluation plan.

• Report on results of intercomparative analysis.

3. TEST AND EVALUATION

3.1 TEST PLAN

A data system test plan is being prepared by the software contractor concurrently with system design for review and approval by NORDA. This plan will specify precisely what constitutes an acceptable test at each of the three testing levels:

(1) Stand-alone system testing;

(2) End-to-end interface testing;

(3) System performance testing.

The stand-alone system testing will verify that software and hardware have been successfully integrated and that they function properly in a stand-alone manner. The end-to-end interface testing will verify that data can be transferred between APL, NORDA, and FNOC as specified in the requirements. The system performance testing will verify that the system will produce reasonable products given accurately simulated altimeter data. NORDA is conducting a simulation employing SEASAT and GEOS-3 data, and NRL (with APL support) is responsible for preparing a standard test tape of GEOSAT-like data. Also, the timeliness and machine resource constraints will be verified with realistic simulation data. NORDA will cooperate with FNOC by supplying simulated wind and wave data, when available, and consulting on throughout testing of FNOC operational marine wind and significant wave height analysis software.

The software contractor will prepare testing tools and plans, and then perform the testing. NORDA and its advisors will review the results. Testing should be complete by September 1984.

APL presented a plan for testing their portion of the GOAP information processing system in their Data Link Program Plan [1]. The only details shown there are for

data link software verification and validation. Additional information on the APL test plan was discussed with NORDA in March, 1984. Similar testing will be necessary for the FNOC portion of the system. That testing will primarily be the responsibility of FNOC personnel, with NORDA providing technical support. An estimate of the required FNOC effort for software (development, conversion, testing), hardware, and security-related activities is given below:

FY-84: 0.3 man/years, $37.1K;

FY-85: 0.4 man/years, $38.3K;

FY-86: 0.3 man/years, $34.9K.

In addition, costs for telecommunications line setup and equipment rental by FNOC may reach $42K. The FNOC personnel involved to date or likely to be involved include Jim Cornelius, Ron Gill, Sue Glassner, and John McKie. These estimated costs are not currently identified budget items. They are shown here only for completeness and to assist in planning.

The field verification portion of the testing will be coordinated with the 6.1 GEOSAT program. To support the verification of GEOSAT-deduced dynamic topographies, several hydrographic and dynamic data types will be collected in the mesoscale demonstration region. These data will consist of both AXBT flights (out of Pax River) and several shipboard CTD surveys. As well, advantage will be taken of existing current meter and inverted echo sounder/bottom pressure gauge arrays already or soon to be implanted in the northwest Atlantic region. These existing arrays will be supplemented with additional sites. The data will be used to support studies aimed at the inference of subsurface thermal structure from the observed dynamic topographies.

3.2 Data System Operation and Evaluation

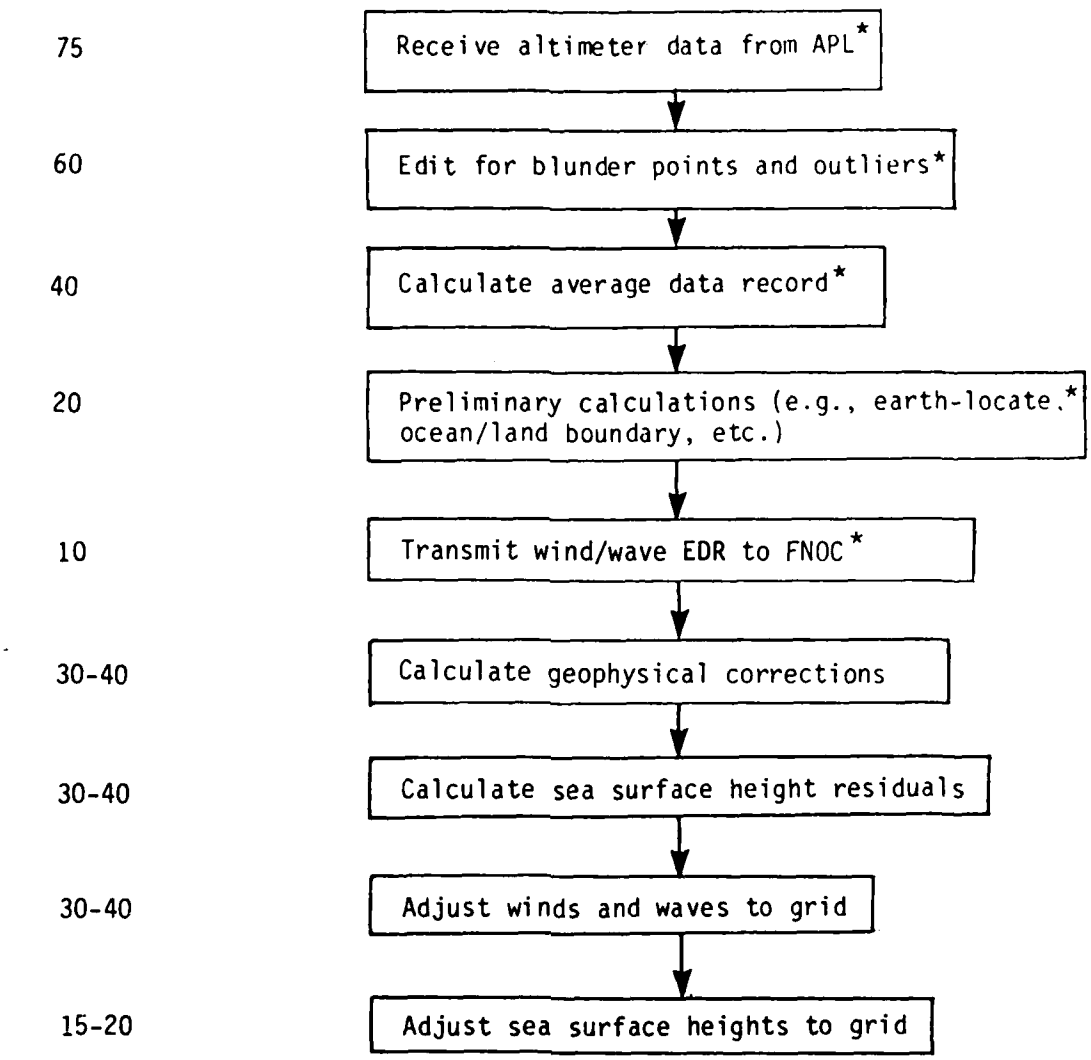
3.2.1 Procedures

After launch the evaluation of the system will consist of an initial verification that the requisite data products can be produced on the specified time line, with real data. This will be followed by a comprehensive months-long evaluation of the data products.

The preparation of the data products themselves will be a complex procedure that involves the cooperative efforts of a number of people. Table 3.1 lists the steps that will go into the production of the oceanographic data products. Figures 3.1.a and b show timing estimates for various stages of the process of turning raw data into products. It will be noted that some steps are keyed to data transmissions from APL to NORDA (whose times depend on when the satellite is in view of the receiving station), while other steps are more conveniently performed at certain times of day. Each day, an analyst at NORDA will evaluate the daily product before transmission to FNOC. Also, copies of the data will be studied by other Navy and contractor analysts to assess the data in a more "off-line" mode. Every month, a data product quality evaluation meeting will be held at NORDA where the problems and progress of the past month will be summarized and documented. This monthly product quality report will be prepared by both the "on-line" analysts working at NORDA and the "off-line" analysts working elsewhere.

Table 3.1 Operations performed at NORDA during demonstration and evaluation phase.

- Receive and decrypt GEOSAT altimeter data.
- Receive FNOC XBT reports and fields.
- Acquire satellite IR imagery (NORDA satellite receiving station).
- Perform editing and averaging of altimeter data.
- Apply geophysical corrections to altimeter data, including SSM/I water vapor range correction when available.
- Navigate and register satellite imagery.
- Prepare warmest-pixel composites from imagery; archive.
- Transmit surface wind speed and significant wave height to FNOC immediately after receipt.
- Calculate ice edge flag; transmit to FNOC daily.
- Calculate sea surface height residuals from altimeter data; merge with warmest pixel composites and other supporting data.
- Perform interactive analysis/interpretation using altimeter height residuals, IR composite imagery, other imagery (e.g., VAS), in situ measurements, historical data, to detect and track fronts and eddies.
- Prepare fronts and eddies product, transmit to FNOC every 24 hours (M-F).



NOTES: 1) Timings are for 12 hours of altimeter observations.
2) Data processing for many of these operations is automatic (unattended); shown by *.
3) Time estimates include data management steps.

Figure 3.1.A. Operations keyed to altimeter data reception.

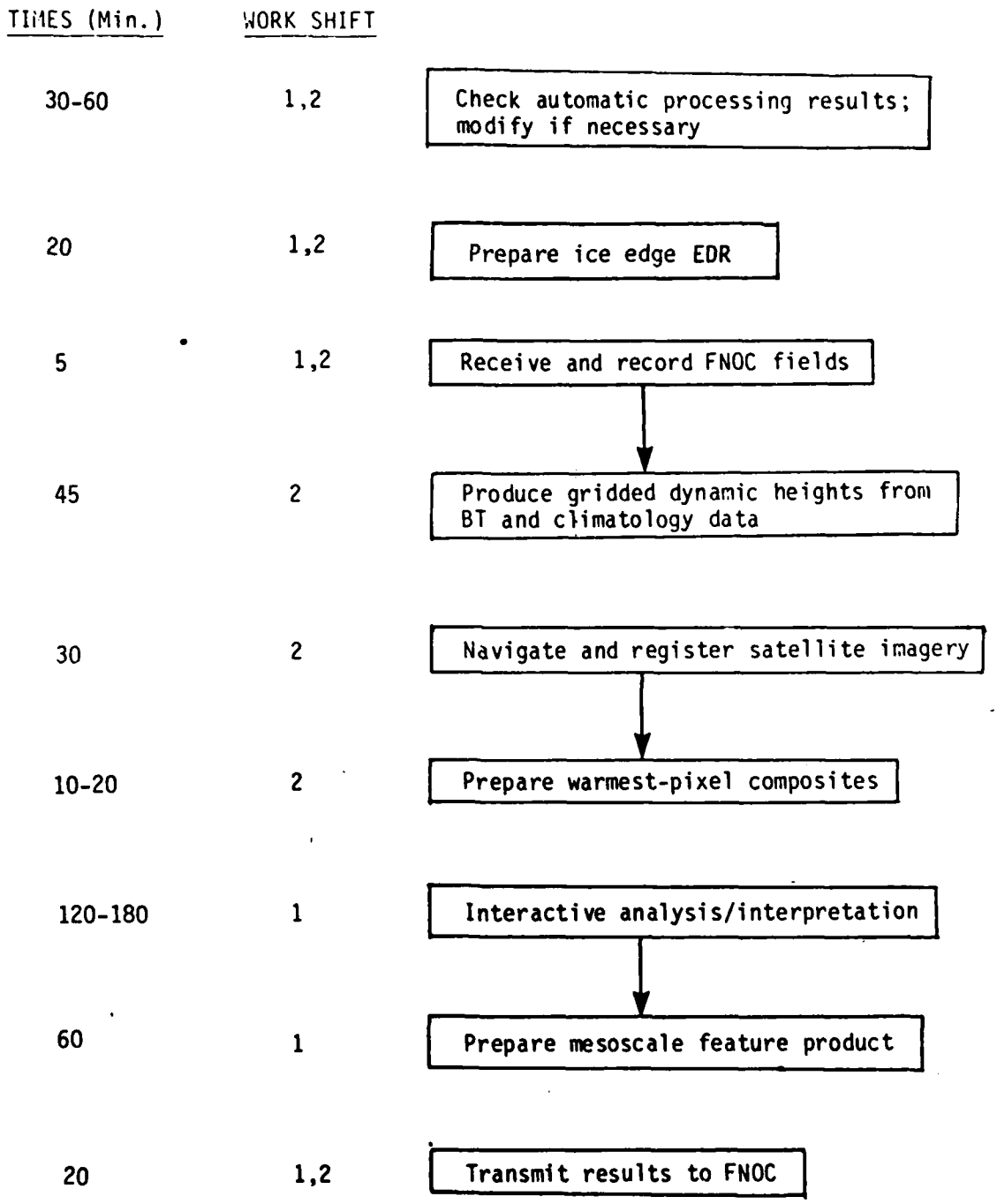


Figure 3.1.B. Operations keyed to times of day.

Table 3.2 shows a typical 48-hour schedule for GOAP processing. It begins at noon (Central time) and arbitrarily assumes that a satellite data dump begins then. Data dumps will not occur exactly every 12 hours. Each interval will be different, but to a first approximation they will alternate between 9 hrs 40 min and 13 hrs 55 min. There will be some occasions when, because of the receiving station/satellite-viewing geometry, there will be insufficient time to receive all the data gathered since the last data dump. In such cases, the remaining data (plus that gathered since the partial dump) will be received on the next orbit. Such a situation is referred to as a "split pass" condition. Table 3.2 takes into account all of these factors.

3.2.2 Product Generation, Formats, Algorithms

Surface windspeed and significant wave height will be provided in the NDR, as described in Reference 13. Consequently, the NORDA processing will consist of editing to identify and delete bad values, and averaging to reduce the significant wave height data rate to 1 sample per second (windspeed is supplied in the NDR at that interval). The simple processing is consistent with the requirement for prompt transmission to FNOC.

The requirement for ice edge information was imposed recently [14]. NORDA's Polar Oceanography Branch will conduct tests during FY-84 designed to "tune" the algorithm developed by Dwyer and Godin [19]. NORDA will use the resulting algorithm to calculate the ice edge flag that will be transmitted to FNOC during the operational demonstration. The Dwyer-Godin algorithm makes use of AGC and late gate information. The current definition of the NDR [17] specifies that AGC information will be provided at a 10 per second rate but VATT, the only available late gate parameter, will be provided once per second. Recent discussions with APL have determined that the AGC electronics have a 0.7-second time constant, so quantities derived from the AGC may not be meaningful at intervals shorter than this. Consequently, ice edge information will be calculated once per second.

The mesoscale analysis will contain an objective component and a subjective component. The former essentially consists of producing clean, Earth-located sea surface residuals, detrended for removal of long-wavelength errors (e.g., orbit error). Earth-location of the satellite by means of an ephemeris calculation will permit the calculation of the difference between the radial component of the satellite's position and the altimeter range measurement; this difference is the elevation of the sea surface above the center of the Earth. This quantity will then be differenced with a high-precision NAVOCEANO geoid and corrected for geophysical errors, orbit determination error, etc. The result is the (residual) sea surface height above (or below) a "level surface" (gravitational equipotential). The residuals will be calculated at one-second intervals (by averaging ten incoming samples) within a selected test area where a high-precision NAVOCEANO geoid exists. Figure 3.2 shows the test area. Both the altimeter range measurements and the NAVOCEANO geoids are classified SECRET.

It was pointed out in Section 2.2.2 that interactive image processing will be a key part of the mesoscale analysis. Sea surface height information from the altimeter will be combined with several other data types: "warmest-pixel" cloud-reduced composites of satellite IR imagery [8], bathymetry, XBT observations, fields of FNOC analysis results (e.g., EOTS), and other data. Different data types become available at different times. FNOC's files of XBT observations are updated frequently throughout the day. Full-scale runs of EOTS are made daily at 0130 Z. The resulting analysis fields are available at approximately 0200 Z. The spot reports that are used as

Table 3.2. 48-hour GOAP processing time line.

NOTE: Time of day is Central Time. Schedule begins with a satellite data dump, (arbitrarily) starting at noon.

TIME FROM START	TIME OF DAY	EVENT
0000	1200	Data dump begins
0055	1255	NDR at NORDA
0155	1355	ALT processing done
0400-0430	1600-1630	Shift change
0430-1200	1630-2400	Prepare composites; other routine operations
1200	2400	Second shift begins
1355	0155	Data dump begins
1510	0310	NDR at NORDA
1635	0435	ALT processing done
2000	0800	First shift begins
2000-2400	0800-1200	Review results; make corrections; perform mesoscale analysis
2400-2800	1200-1600	Transmit mesoscale analysis to FNOC
2335	1135	Data dump begins
2430	1230	NDR at NORDA
2530	1330	ALT processing done
2800-2830	1600-1630	Shift change
2830-3600	1630-2400	Prepare composites; other routine operations
3600	2400	Second shift begins
3730	0130	Data dump begins*
3810	0210	(Partial) NDR computed
3910	0310	Data dump begins*
4025	0425	NDR at NORDA
4150	0550	ALT processing done
4400	0800	First shift begins
4400-4800	0800-1200	Review results; make corrections; perform mesoscale analysis
4710	1110	Data dump begins
4800	1200	NDR calculation in progress; begin transmission of mesoscale analysis to FNOC

*Split pass

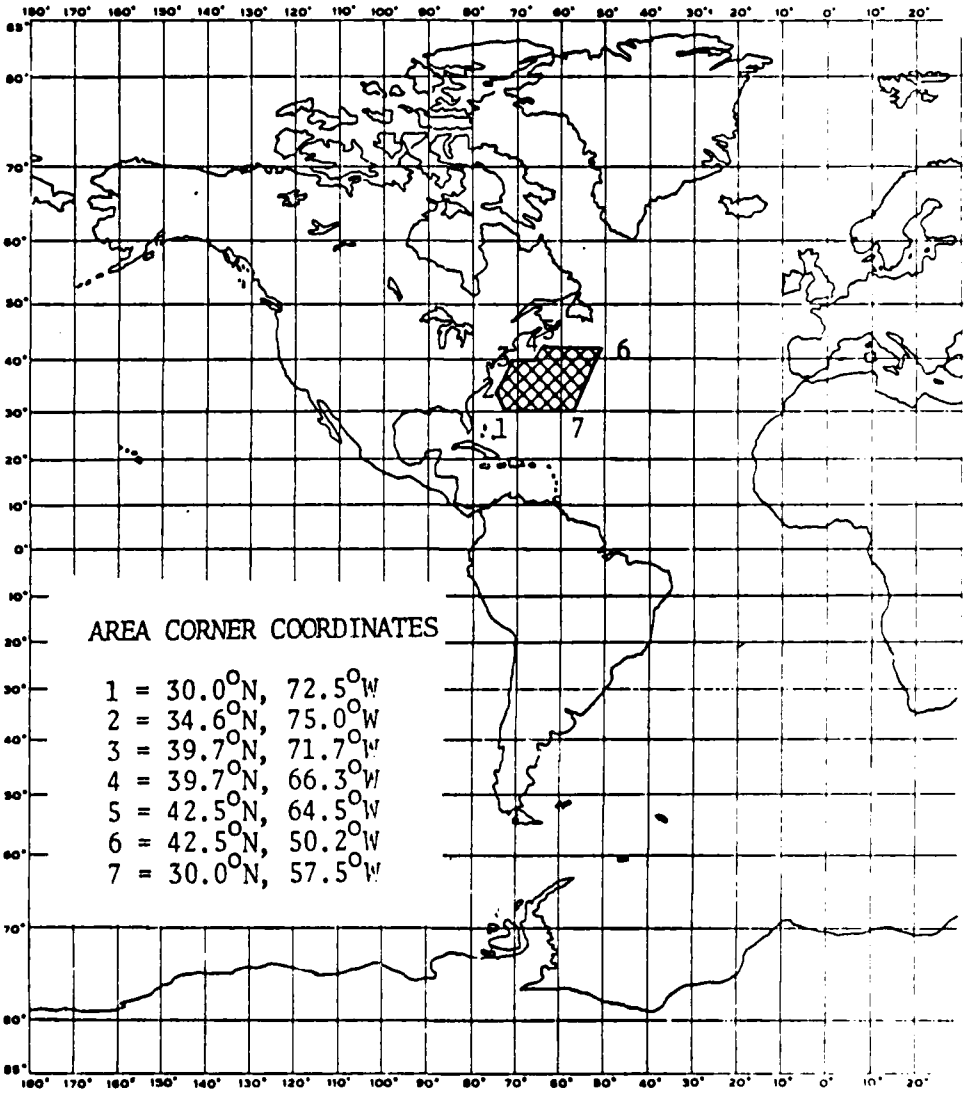


Figure 3.2. Test area for calculation of GOAP mesoscale product.

input to EOTS come in throughout the day; those reports are also available. Some other FNOC analysis fields that may be used are: A29$ and A30$, u and v components of marine winds, run at six-hour intervals starting at 0420 Z; A01$, surface pressure, run at same times as A29$ and A30$ (12-hour prognostic fields are available at any time); A10, surface air temperature, run at 0500 Z and 1700 Z; and A12$, surface water vapor pressure, run at 0500 Z and 1700 Z. The feasibility of obtaining precipitable water data from NIMBUS-7 SMMR and NOAA series TOVS to use in calculating the tropospheric water vapor path length correction is being investigated. A subjective determination of the mesoscale feature content will be made by interpretation of the above data, comparison with other days' results, etc.

The raw altimeter height words and the geoids will be classified SECRET. Consequently, the telecommunications line between NORDA and APL, and NORDA's GOAP computing facility, must be operated in a classified mode. It is assumed at this time that the mesoscale product will be classified. Many of the XBT reports to be obtained from FNOC are classified. So it is also planned for the communications link between NORDA and FNOC to be classified. Figure 3.3 shows a block diagram of the APL-NORDA-FNOC information processing hardware, including the communications links.

The windspeed, wave height, and ice data will be transmitted to FNOC in the form of a SEAFORM [4] environmental data record (EDR). Some format modifications will be necessary. As described in Reference 4, SEASAT altimeter geophysical data records (GDRs), for which SEAFORM was written, only contained wave height information. A review to determine the needed changes is in progress.

FNOC [6] stated a requirement "that ocean feature information be sent in a digital form suitable for direct assimilation into the Expanded Ocean Thermal Structure (EOTS) analyses." The existing EOTS bogus capability requires sea surface temperatures (SSTs) or temperature gradients. The GEOSAT altimeter will provide information on sea surface topography; in cloud-covered regions where there are no surface observations, no other information may be available. Consequently, it will be necessary to infer thermal gradients from the surface elevation measurements provided by the altimeter. This is a 6.1 or 6.2 problem, and this aspect of the GEOSAT data assimilation must be regarded as a weak link in the system; an operational capability will not be ready until the FY-86/87 time frame. Other work directed toward the objective assimilation of altimeter-derived sea-surface heights was described in Section 2.2.2.

The entire question of assimilation at FNOC of information provided by GEOSAT is critical to the success of GOAP. GEOSAT will potentially provide significant increases in certain types of information, which, in turn, might lead to some changes in procedures. Actual experience with the data is the only practical way to evaluate the utility of GEOSAT; proper design of the tests is important. A multistage plan for the assimilation of the data from GEOSAT (and later satellite altimeters) is envisioned, of which the first two stages can be defined now.

Briefly, those two stages are:

(1) Assimilation into, or other use with, existing FNOC models.

(2) (First round of) possible modification of existing analysis methods or implementation of new ones.

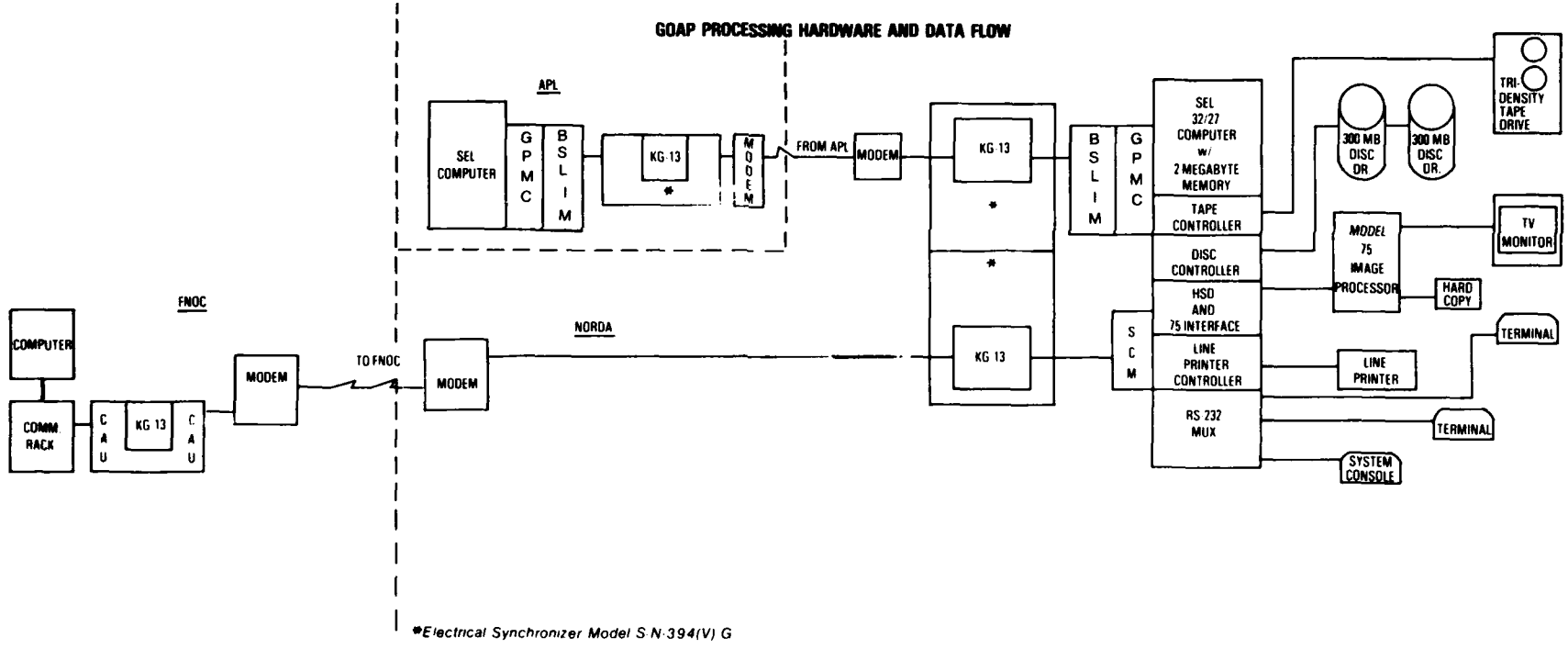


Figure 3.3. GOAP processing hardware and data flow.

For the first stage, the most likely use of wind data is as input to the Marine Wind analysis [3]. NORDA understands that some capability to ingest significant wave height data exists; additionally, a historical comparison with SOWM data would be useful. A potential use of the ice product is to produce a plot of the ice edge. It is believed that existing FNOC software could be used or adapted. As discussed above, the mesoscale feature information is intended to be used as input to EOTS or OTIS, but the capability for such usage will not be ready in the initial part of the operational demonstration.

The ideas for stage 1 are based on discussions between NORDA and representatives of other organizations, primarily Jim Cornelius, Mike Clancy, and Leo Clarke of FNOC, Tom Kleespies of NEPRF, and Sheldon Lazanoff of Science Applications, Inc. NORDA intends to pursue the development of the assimilation methods to derive maximum benefit from the GOAP data. NORDA also intends to work with FNOC and NEPRF to study some reservations that have been expressed concerning the assimilation of surface scalar winds from GEOSAT into the Navy Operational Global Atmospheric Prediction System. Briefly, these reservations include the following points: GEOSAT data dumps occur about twice a day, not necessarily near NOGAPS update times. So, very little wind data transmitted to FNOC may be sufficiently "fresh" to be within the cutoff window for the analysis. Because of this and the nature of the ground track, the net effect might be the assimilation of data with wave number 14. Also, a surface wind analysis is not performed by NOGAPS (although NORDA understands that NEPRF is planning for a NOGAPS upgrade that includes use of winds), and surface winds are not used to initialize the forecast model. NOGAPS diagnostically computes the ocean surface winds from the free atmospheric prognostic equations, and requires a vector wind field rather than scalar winds.

Considerations such as these will influence future developments in the assimilation of altimeter data. For the first set of modifications or enhancements to existing analysis methods, NORDA is evaluating and will probably support some of the proposed efforts listed below, from Reference 7. The numbers identifying tasks in the following list do not necessarily correspond to the task numbers in Reference 7:

(1) Develop an algorithm to compute wind wave and swell heights from significant wave heights and wind speeds measured by the GEOSAT altimeter.

(2) Compare FNOC Global Spectral Ocean Wave Model (GSOWM) SWHs with SWHs from the GEOSAT altimeter and buoys. Conduct a detailed error analysis of the GSOWM output so that when the task is completed, the analysis indicates the direction to be taken for improving the operational computer models.

(3) Develop algorithms to compute GEOSAT one-dimensional (energy vs. frequency) wave spectra using GEOSAT windspeed and SWHs and FNOC meteorological analyses.

(4) Compare wave spectra derived from altimeter data to SOWM and NDBO wave spectra.

(5) Evaluate the GEOSAT altimeter backscatter data as a possible source of ambient noise information for use in acoustic prediction models.

Table 3.3 is a chart that contains estimates of the usage of NORDA information processing system resources for each major function during normal operations. Items included are "wall clock" time (cpu time will be less), disc storage, telecommunication lines, I^2S image processing station usage, tape storage, and line

printer and hard copy device utilization. Numbers in the table indicate the average effect of one day's operations. Normally, several days' accumulation of working files will be retained on the disc, with backups to tape for archival purposes made periodically.

One potentially important geophysical error source is the range error induced by tropospheric water vapor. The SEASAT SMMR was able to provide a reasonably good correction. An alternative correction that was used for SEASAT, based on FNOC fields, did not have sufficient spatial resolution to be of use in the mesoscale range. GEOSAT will not carry any remote sensors other than the altimeter, and there probably will not be any SMMRs in operation during the GEOSAT mission. The DMSP SSM/I, which is scheduled to be launched several months after GEOSAT, is a similar instrument. NORDA is working with NRL in the development of an algorithm to calculate the tropospheric water vapor range correction from SSM/I measurements. When this is operational, water vapor corrections will be utilized in GOAP, as shown in Table 3.1. A separate NORDA Remote Sensing Branch project to develop a procedure for using NOAA AVHRR data to derive an interim water vapor correction is proceeding and showing some successful results.

3.3 SYSTEM INTEGRATION AND TESTING

3.3.1 System Description

The portions of the overall GOAP system of primary interest to NORDA are communications link (APL-NORDA and NORDA-FNOC) hardware and software, and NORDA processing hardware and software. The communications link hardware consists of computer interface units, encryptors/decryptors, modems, and communications lines. The encryptors/decryptors are GFE and will be obtained by NAVELEX and CNOC. The interface units, communications lines, and modems will be provided by the GOAP project and CNOC. APL will write the communications software for the APL-NORDA link. The NORDA processing hardware is described in Table 2.1, and Figure 3.4 shows the floor plan for equipment layout. The processing hardware is being procured separately, funded in part by OP-952 FY-82 funds. The NORDA GOAP processing software will be developed as discussed in Section 2.2.2, and supported by GOAP (SOTA) funds.

NAVELEX is providing the APL-NORDA telecommunications link. A TSR was forwarded to NAVTELCOM in December 1983, for the DDS-quality line, modems, and hookup. Arrangements for the NORDA-FNOC line are being handled by CNOC.

3.3.2 Personnel

During the planning and implementation phases, tasks are being performed by NORDA analysts and contractor personnel with NORDA coordination. APL is providing technical support for the conversion of the line control software to NORDA's computer, for the procurement and installation of the 9.6 kb/s line and modems at APL and NORDA, and for the installation of the data line encryptor, decryptor, and Crypto Ancillary Unit (CAU) if needed. NORDA and its software contractor are responsible for the design of the software system functional and detailed requirements. The software contractor is responsible for the design and implementation of the computer software modules, for preparation of the system test plan, and for system testing. NORDA is also being assisted by several outside consultant/advisors, chosen for their unique capabilities and talents. Among these are NAVOCEANO personnel.

Table 3.3. GEOSAT system loading estimates.

OPERATIONS	TIME REQ'D (MIN)	DATA RATES (BPS)	% OF DAY	DISC STORAGE (MB)	% CAP	COMM. LINES NORDA/ APL (%)	COMM. LINES NORDA/ FNOC (%)	M75 DISPLAY HRS	TAPE	PRINTER PP.	HARD COPY	REMARKS
COMMUNICATIONS												
NDR INGEST	120	9600	8.33	7.5	1.56	8.33	0	0	0.2	0	0	APL COMM & NDR FILE MGMT
BATHY & FIELD INGEST	4	9600	0.28	0.3	0.06	0	0.28	0	0	0	0	FNOC COMM & FILE MGMT
WIND/WAVE/ICE XMIT	5	9600	0.35	1.3	0.27	0	0.35	0	0	0	0	FNOC COMM & FILE MGMT
MESOSCALE XMIT	TBD											MAY SEND AS MESSAGE
DATA PROCESSING												
TIME CORR & TIME EDIT NDR	4		0.28	7.5	1.56			0	0	0	0	TCTE
EARTH LOCATE	15		1.04	1.0	0.21			0	0	0	4	PPTI
LAND/SEA EDIT	7		0.49	1.1	0.23			0	0	0	0	LSE
DATA QUALITY EDIT	72		5.00	0	0			0	0	2	0	DQE
DATA AVERAGE	48		3.33	1.5	0.31			0	0	0	0	AVERAGE
WIND/WAVE EXTRACTION	2		0.14	0	0			0	0	10	4	WWE
ICE PRODUCT	2		0.14	0	0			1	0	10	2	ICEP
AREA OF INTEREST EDIT	2		0.14	0.1	0.02			0	0	0	0	AOIE
TIDE MODEL CORRECTIONS	15		1.04	3.0	0.63			0	0	0	0	RPTIDE
GEOID CORRECTIONS	7		0.49	1.0	0.21			0	0	0	0	GEOID
EM BIAS CORRECTIONS	2		0.14	0	0			0	0	0	0	EMBC
TILT & BIAS CORRECTION	10		0.69	0	0			0	0	0	0	TBC
CALC. SEA SURFACE HT.	5		0.35	0	0			0	0	40	4	CSSH

Table 3.3 (continued). GEOSAT system loading estimates.

OPERATIONS	TIME REQ'D (MIN)	DATA RATES (BPS)	% OF DAY	DISC STORAGE (MB)	% CAP	COMM. LINES NORDA/ APL (%)	COMM. LINES NORDA/ FNDC (%)	M75 DISPLAY HRS	TAPE	PRINTER PP.	HARD COPY	REMARKS
MAKE WARMEST PIXEL COMPOS-ITE (WARP)	120		8.33	120.0	25.00			4 HRS	2	0	?	SYSTEM 575
SUBJECTIVE ANALYSIS	60		4.27	12.0	2.50			4 HRS	1	0	?	SYSTEM 575
PROGRAM DEV/MOD/ CKOUT	0-4HRS		0-16.67	0.1	0.02			?	?	?	?	SYSTEM 575
DATA STORAGE LAND/SEA FILE				63.3	13.18							CIA WORLD DATA BANK 2
BATHYMETRY FILE				18.7	3.90							SYNBAPS
GEOID FILE				37.3	7.77							
TOTALS	500-740 MIN		34.7-51.4%	275.7MB	57.4%			9 HRS	3.2	62PP	14	

NOTE 1. Figures show amount consumed or expended, added, or required for use in one 24-hour period.
NOTE 2. Some operations could be performed simultaneously, which would reduce total "time required".
NOTE 3. Some processes will be performed by the computer in unattended mode.

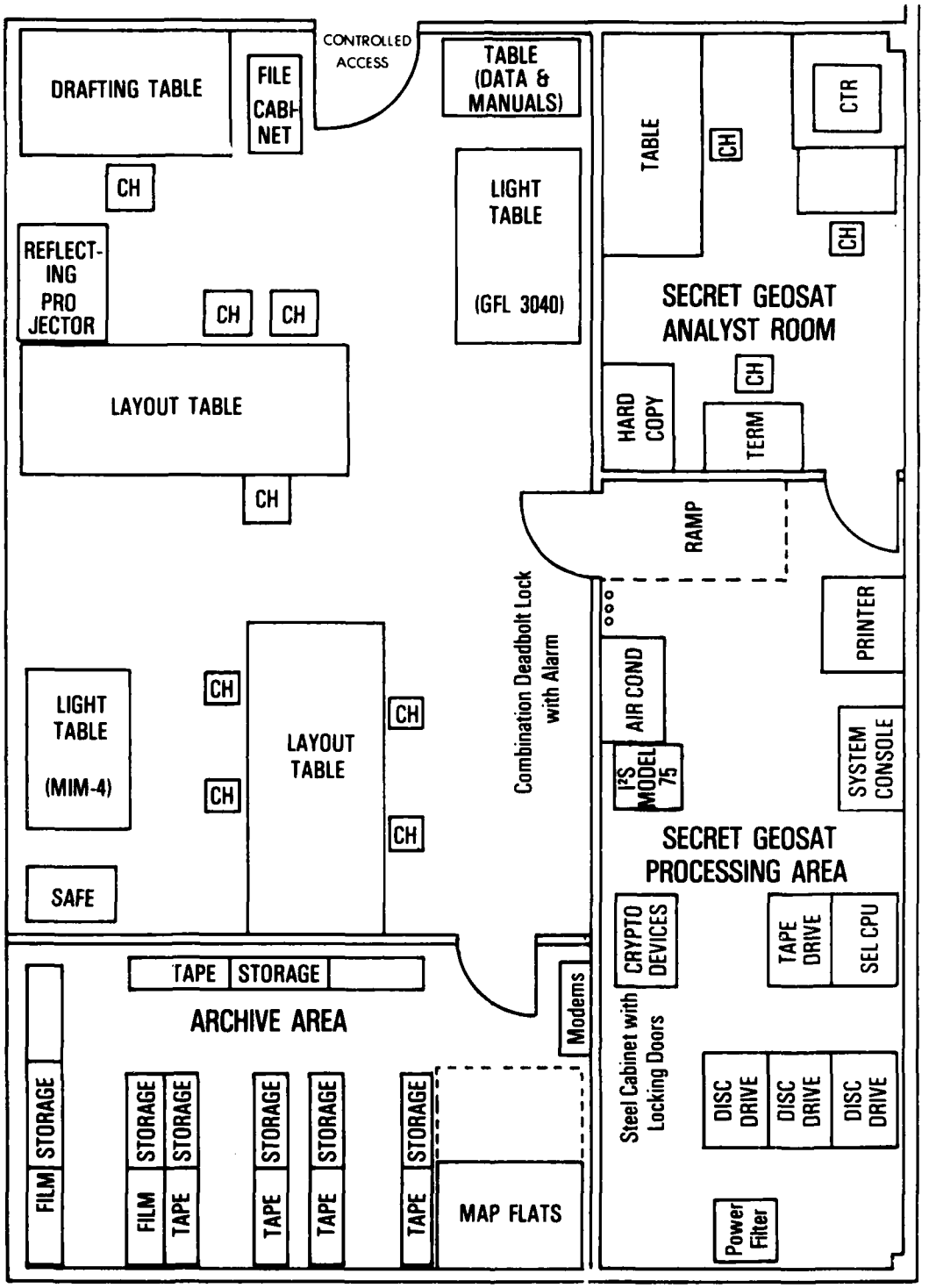


Figure 3.4. Floor plan for NORDA GOAP processing facility.

During the demonstration/evaluation and operation phases, the system will be operated by NORDA analysts and (a minimum of) two contractor personnel. The former will conduct the oceanographic analyses--primarily, detection and monitoring of mesoscale features--while the latter will perform the support tasks listed in Figures 3.1 a and b. Normal operation will consist of two shifts, five days a week. The contractor personnel will work the second shift.

During this period the evaluation of the system will consist of an initial verification that the requisite data products can be produced on the specified time line, with real data. This will be followed by a comprehensive evaluation of the quality and utility of the data products. FNOC, NAVOCEANO, and others will cooperate with NORDA in the evaluation.

The quality of the data products will be evaluated by qualified oceanographic analysts working at NORDA and elsewhere. Each day analysts will determine that the products are in reasonable accord with data from satellite IR sensors, with XBT data, with previous GEOSAT data, and with current mesoscale-resolving circulation models. To facilitate this evaluation the GOAP information processing system will have access to all the above-mentioned data types plus wide variety of graphics and manipulative capabilities to recall, display, and merge current and historical data.

The utility of the data products will be evaluated primarily by analysts at FNOC and the regional centers. Analysts at these locations will determine to what extent these GOAP data products can be used to generate improved FNOC "now casts" and forecasts in an operational environment. Likewise, the regional centers will determine to what extent these data products are useful in preparing their own more specialized data products. Basically, the analysts at FNOC and at the regional centers will determine whether or not their deliverables are improved through the use of GOAP data products. In some cases the GOAP data products may be directly useful to Navy line elements such as the P3 squadrons. In this case these users would be contacted for their response to the GOAP data products. The FNOC and regional center analysts will prepare a bimonthly report on GOAP data utility.

3.3.3 Orientation Plan

Orientation and training will be performed by three methods:

(1) On-the-job experience with the system acquired during pre-test development and operation of the system.

(2) Formal instruction on the system by the principal investigator or the information processing system contractors(s).

(3) Detailed written instruction in the form of a user's manual.

3.3.4 Testing

The different elements of the test procedures have been discussed in previous sections. It should be noted that the development of a detailed test plan is an important part of the information processing system development. Plans for system testing and evaluation are being developed concurrently with the system design. Prior to launch, simulated GEOSAT data can be used in the testing. NRL/APL has prepared a simulated data tape using synthetic data. In the near future, NRL/APL plans to prepare a new tape containing data obtained in simulator tests of the GEOSAT altimeter.

3.3.5 Transition to FNOC or NAVOCEANO

NORDA is committed to a 12-18 month operational evaluation with analysis to be performed at NORDA and results transmitted to FNOC. Subsequently, in accordance with original guidelines and References 20 and 21, the responsibility for processing and analysis will be transferred. The schedule for the transition will be keyed to the schedule for the FNOC Satellite Processing Center (SPC) upgrade, if FNOC is selected to continue the GOAP processing. NORDA, APL, and its contractors will provide technical support for the transition, and will strive to prevent any interruption of the analysis during that time. It is planned that the decision when to transfer this function will be made after the value of GEOSAT data is determined and communicated to all parties concerned.

3.3.6 Extended Exact Repeat Mission

The primary GEOSAT mission is the collection of global sea surface topography at a cross-track spacing of approximately 5 km. These global data will be averaged to compute a mean sea surface topography in order to approximate the long-wavelength components of the marine geoid. This primary mission is sponsored by OP-211. The (secondary) oceanographic mission (GOAP), outlined above, is sponsored by OP-952.

The nominal geodetic mission will be completed in approximately 18-20 months. Subsequently, GEOSAT may be maneuvered into a slightly different orbit whose ground track "laydown" would have characteristics more favorable for sampling the oceanic mesoscale field, and could provide useful information even in areas where no precise geoid exists. This proposed extended, exact repeat mission (ERM) is discussed by Mitchell [15]. NORDA would be involved in the processing for the ERM.

Should such an extended, exact repeat mission be realized it is likely that the mesoscale product would be expanded to global coverage. The processing and interpretation of the data may be somewhat simplified given the exact repeat nature of the ground tracks during the proposed extended mission, though the volume of data to be handled will clearly be increased. More specific estimates of the impact of an extended GEOSAT-A mission on the GOAP will be forthcoming in the next revision of this Test and Evaluation Plan.

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NORDA's Remote Sensing Branch will conduct an operational demonstration as part of the GEOSAT Ocean Applications Program (GOAP). The purpose of the demonstration is to evaluate the extent to which oceanographic products can be derived from altimeter data in near real-time. This technical note describes the information processing system that will be used for this task, and plans for its development and testing. It also covers plans for the operation of the system, personnel assignments and training, evaluation of the products, and eventual transfer of the operations to FNOC or NAVOCEANO.

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